STRATEGY FOR RECONSTRUCTION OF LABORATORY BASED XFCT

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Summary: X-ray fluorescence computed tomography (XFCT) is an emerging technique to retrieve the elemental distribution in objects. In this work, we present one strategy to remove the absorption effect and retrieve reliable density information of trace elements when projection data is collected using laboratory based XFCT. Through testing on numerical simulation data, this method has been evaluated.

1. INTRODUCTION

As a stimulating emission tomography technique, X-ray fluorescence computed tomography (XFCT) stimulates the generation of fluorescence X-rays with an incident X-ray beam of sufficient energy. By detecting the energies of the fluorescent X-rays emitted from the sample, elements present inside the specimen can be identified. By stimulating the object at different translation positions and different projection angles, a first-generation tomographic sinogram is acquired. Reconstructing sinograms acquired in XFCT allows for 3D visualization of the elemental distribution inside specimens.

Although most commonly performed using monochromatic radiation from a synchrotron X-ray source, significant progress has been made on laboratory based XFCT scanners [1] in recent years. To date, reconstruction of projection data collected from laboratory based XFCT scanners is carried out with algorithms like Filtered Back Projection (FBP) or Maximum Likelihood Expectation Maximization (MLEM). Such algorithms have failed to present an accurate correction for the self-absorption effect in XFCT. Particularly for polychromatic incident beams used in laboratory based XFCT scanners, it is impossible to retrieve quantitative information of elements with those methods.

In this presentation, we propose a strategy to reconstruct the density of the elements of interest in an object when they are present in trace quantities and the matrix material of the sample is known beforehand using laboratory-based XFCT.

2. METHOD

In order to acquire density information of the trace elements, correction for the attenuation of the incident X-ray beam as it passes through the sample as well as the attenuation of fluorescent X-rays as they escape the sample is needed. In synchrotron XFCT, attenuation of the incident X-ray beam can be obtained with X-ray transmission tomography using the same monochromatic beam. However, this is not possible in laboratory based XFCT due to the usage of polychromatic X-ray sources. In order to allow for quantitative XFCT, we assume the self-absorption effect is dominated by a known matrix material. With this assumption, the local density can be retrieved quantitatively from (polychromatic) transmission tomography using dedicated reconstruction methods [2]

With access to the density of the matrix material, attenuation of both incident X-rays and fluorescent X-rays can be calculated straightforwardly. By embedding such information in reconstruction algorithms developed for emission tomography, quantitative information of trace elements inside the sample can be acquired from projections recorded on a laboratory based combined transmission and fluorescence CT scanner [1].

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3. RESULTS AND CONCLUSIONS

As a preliminary work, we have tested our method on a biomedical phantom introduced in [3]. Specifically, we have set the physical size of the phantom to $5mm \times 5mm$ and discretized it on a 100×100 grid. Both transmission projection data and fluorescence projection data are simulated with an in-house developed software using a first-generation tomographic geometry. For both image modalities, we have simulated 120 projections and 300 translation positions have been considered at each projection angle.

Following the strategy described in the previous section, selected outcomes have been presented in figure 1. As can be observed in figure 1.d, the absorption effect is distinct when reconstructing the sinogram with MLEM. Nevertheless, figure 1.e proves such artefacts can be removed with the strategy introduced in this work. Comparing two lines presented in figure 1.f, we conclude the density information of Zinc can be retrieved with decent quality even though the sample is illuminated with polychromatic X-rays.

In summary, we have proposed a reconstruction strategy for laboratory based XFCT and validated its correctness with numerical data. To further assess its quality and its robustness, we will test its performance on experimental data collected from a laboratory based fluorescence CT scanner in the near future.

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References

[1] Laforce, Brecht and Masschaele, Bert and Boone, Matthieu N and Schaubroeck, David and Dierick, Manuel and Vekemans, Bart and Walgraeve, Christophe and Janssen, Colin and Cnudde, Veerle and Van Hoorebeke, Luc and others. Integrated three-dimensional microanalysis combining X-ray microtomography and X-ray fluorescence methodologies, *Analytical chemistry*, 89, 19, 10617–10624, 2017

[2] Dhaene et al. An iterative polychromatic algorithm for reconstruction of density information in computed tomography data. In preparation

[3] Yang, Qun and Deng, Biao and Du, Guohao and Xie, Honglan and Zhou, Guangzhao and Xiao, Tiqiao and Xu, Hongjie. X-ray fluorescence computed tomography with absorption correction for biomedical samples, *X-Ray Spectrometry*, 43, 5, 278–285, 2014.

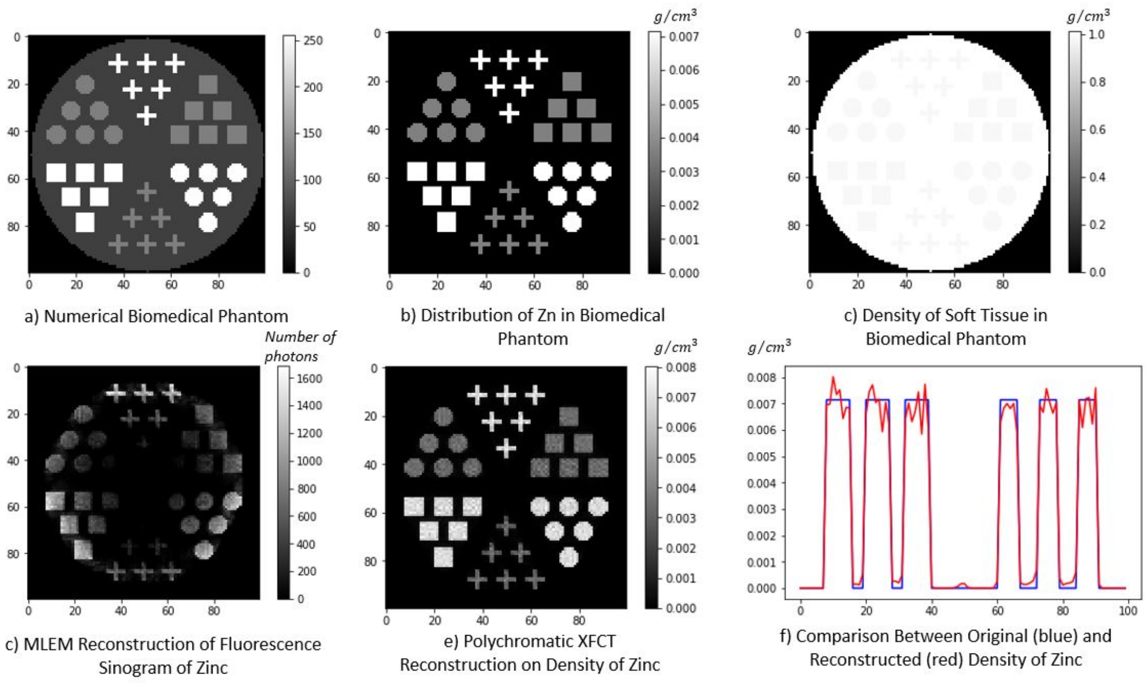

Figure 1: a) Biomedical Phantom Composed of Soft Tissue, Zinc and Iron; b) - c) Ground Truth of Components in Biomedical Phantom; d) - f) Reconstruction Outcome of Biomedical Phantom